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FINAL (AND SEMI-ANNUAL) REPORT

Contract: Far Infrared Radiometry and Spectroscopy of Mars

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Introduction

The University of Hawaii team participated in four flights for the observation of Mars in August 1971. The purpose of our experiment was (a) to measure the thermal flux from Mars at several wavelengths in the far infrared and submillimeter spectral region, and (b) to obtain interferometric spectra of Mars in the same spectral region. The scientific basis of (a) was the discrepancy between the average radiometric temperature computed from the data of Sinton and Strong (1) and the Mariner flights (2) and the millimeter and microwave temperatures (3). In order to carry out this objective we needed an accuracy of 15% in determining the absolute flux from Mars. The spectroscopic observations (b) were to record the presence of water vapor and any other molecular constituents in the Martian atmosphere or surface that might produce absorptions in the spectrum.

Instrumentation

The detector was an adsorption pumped He^3-cooled bolometer and it was mounted on a 12-inch Cassegrain reflecting telescope supplied by the University of Hawaii. A back-up Low bolometer detector was carried on board in operating condition on each flight but was never used, although its noise level was monitored. Black-body calibration sources were provided together with appropriate chopping devices. The telescope was equipped with an oscillating-secondary mirror which provided chopping of the planetary image against the sky at a frequency of 10 Hz. This procedure is the best possible outside of having an oscillating telescope in a windowless port in the aircraft.

Filters used in the project had peak transmissions at 38 μm, 62 μm, and 128 μm. They were of the metal mesh type and were supplied by Descriptive Design and Development Corporation and were contained in the cooled environment of the He^3 detector. A broader-band filter was incorporated in the Low bolometer.

Data were recorded directly on a chart recorder and also integrated and stored in digital form on paper tape.

Provisions had been made for mapping the response characteristics of the detector entrance aperture by a triangular chopping motion of the oscillating telescope secondary mirror and an analog signal-recording system.

Preflight analysis of the performance characteristics of the detector-filter-telescope system together with the transmission characteristics of the aircraft window showed that both experiments were possible after allowing ten-fold degradation of detector performance by the aircraft environment compared to laboratory and/or ground-based telescopic use.

The Observations

Our experiment encountered some difficulties that impeded our ability to carry out the observations with a high degree of success. The two major difficulties are discussed below.

1. Radiometry through a window, as is necessary in the CV-990, is difficult, not only because of the moderately low transmission of the window material itself, but also because of the vignetting of the entrance beam by the metal septum and edges of the window as the angle of view changes slightly with the motions of the aircraft. This introduced a variable signal to the detector, having a magnitude comparable to or greater than the flux of the planet being observed.

2. Vibrations of the aircraft in flight and electronic sources on the aircraft introduced noise into the detected signal because the detector in its dewar could not be completely isolated and still remain mechanically attached to the aircraft rigidly enough to satisfy safety requirements. We had anticipated this problem, and had there been no others, it would not have seriously limited the success of our experiment.

Results

Repeated integrations during the first two Mars flights showed that we could detect Mars with the 62μm filter, but the signal-to-noise ratio was small and the resulting error in the flux much larger than the 15% requirement. The calibration observations of the Moon gave very large and reproducible signals. However, the expected signal from Mars was but 1/600th of that from the small area of the Moon used for calibration. On the last two flights, in addition to the observations, we conducted a series of experiments to correlate variations in our signal level with the roll motions of the aircraft. We were encouraged in this because occasional large roll excursions during the observation period definitely gave substantial signal excursions. The attached figure shows the roll of the aircraft (plotted from the computer output provided to experimenters) together with the signal. We have performed a preliminary correlation test with these data by digitizing roll and signal and analyzing them by cross correlation with a computer. Our initial results are that the correlation is not direct, nor is there good correlation with the time derivative of the aircraft roll. Further studies of these data by introduction of a small time lag (corresponding to the time constant of the data system) may provide better correlation, thereby permitting the reduction of the long-period noise in the detector signal and giving a better signal-to-noise ratio for Mars at the three wavelengths we studied.

Summary and Conclusions

Because of the low signal level detected during the Mars flights, and the ensuing complications in reducing the data, we do not regard the data analysis as complete at the time of this report. Additional computer correlation studies are in progress and it is hoped that a measurable flux can be extracted from the recorded signals, at least for the 38 and 62μm filter bands. Since lunar calibration and black-body calibration runs were also obtained, the extraction of a measurable signal will permit a determination of the Martian surface temperature at these wavelengths. Because the temperature of Mars has been adequately measured by Hanel _et al_. (4) out to 50 μm, the 62μm point will be most important. It is unlikely that the data at 128 μm are good enough to permit a measurement of the temperature.

Although the scientific output from the experiment has not been of value thus far, we have been made painfully aware of our oversight in not considering noise produced from a window by aircraft roll. We advise that subsequent people contemplating near-threshold thermal radiometry give careful consideration to this factor. The windowless design of the C-141 and the Lear Jet telescopes eliminates this problem and is highly commended.

REFERENCES

1. W. M. Sinton and J. Strong, _Ap. J._ _131_, 459, 1960.

2. G. Neugebauer _et al._, _Science_ _166_, 98, 1969.

3. Extensive references but see C. Sagan and J. Veverka, _Icarus_ _14_, 222, 1971.

4. R. Hanel _et al._, _Science_ _175_, 305, 1972.

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